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Trinity River Project

Berkeley, California
July 26, 1956

Memorandum Report

RECONNAISSANCE SOIL EROSION EXAMINATION OF TRINITY PROJECT WATERSHED, SHASTA-TRINITY NATIONAL FOREST

By Clark H. Gleason, Forester

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California Forest & Range Experiment Station,
Forest Service,
U. S. Department of Agriculture

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SUMMARY

A reconnaissance examination of the Trinity Project Watershed was made in May 1956 to appraise the effects of logging and burning upon soil erosion in relation to the expected sediment life of Trinity Reservoir, soon to be built. Road construction and logging were found to be serious causes of accelerated erosion except in a few places where steps had been taken to prevent erosion. Burning was not a serious erosion cause, as recent fires have been few and small.

There are approximately 360 miles of mapped roads in the watershed~~s~~, plus an undetermined mileage of minor roads and logging roads. About 70 miles of the mapped roads will be inundated by the new reservoir, requiring the relocation of some and the abandonment of others. Relocation should be done with the utmost care to prevent erosion; abandoned roads should be "put to bed."

Existing roads are mostly unsurfaced. Their drainage, culvert outfalls, and overcast slopes need improvement locally to reduce erosion. In many places their cutbanks are overhanging and unstable because of road widening; if erosion is to be controlled these banks should be sloped to a stable angle, and some should be planted, or seeded.

Logging practices were generally good on two government sales that we saw. The roads and skidtrails were well located and mostly well drained, and they had caused little erosion. Logging practices on private lands, of which we saw several examples, were generally poor with respect to drainage and soil erosion. Roads and skidtrails

were not well located, there were no cross-drains and few culverts, and they had caused moderate to severe erosion.

Tentative erosibility ratings were assigned to 10 soils examined in the watershed. Soils developed on granite (Jurassic acid intrusive) rocks were found to be highly erosible, requiring the greatest care to prevent acceleration of erosion by road-building and logging. The granite soils occupy about 25 percent of the watershed. Other soils developed on sedimentary, basic intrusive, metamorphic, meta-volcanic, and glacial parent materials were judged to have moderate to low erosibility. This does not mean that soils in the latter categories are erosion-proof, as any of them can be severely eroded after disturbance. The tentative nature of these appraisals is to be emphasized, as observations following the single winter 1955-1956 could not be conclusive.

This study indicates that sedimentation may greatly exceed 0.26 acre-feet per square mile of watershed per year, the expected sedimentation rate taken by the Bureau of Reclamation for calculations of the life of the new reservoir. This rate is less than rates calculated for suspended sediment alone in similar watersheds of western Oregon, and it appears to leave out of account the sand, gravel, and stones that will be deposited in estuaries of the reservoir. A neighboring reservoir showed a rate almost 3 times the 0.26 figure before its watershed was disturbed by logging and fire. The relocation of existing highways could cause erosion initially at rates of 1 to 62 acre-feet per mile of road per year, judging from rates measured on highways in central and southern California. In addition, there can be severe erosion on minor roads, and on logging roads and skidtrails. Additional study, including considerable field work, would be needed to develop firm estimates of probable erosion in lieu of the 0.26 figure.

To keep reservoir sedimentation at a minimum, future management of this watershed will require careful planning and supervision of road-building and maintenance, logging, and other land uses that disturb the plant cover and the soil. The means of preventing erosion are known; the challenge is to apply this knowledge consistently through the years.

Ownership of well over half of the private land by one company, the Southern Pacific Railroad, offers an unusual chance for a cooperative approach in solving the watershed management problems. This might logically involve developing the government and Southern Pacific lands together, and setting an example of good practices for other private operators to follow.

INTRODUCTION

A reconnaissance examination of parts of the 680 square mile watershed of the Trinity River above Trinity Dam Site in Sec. 15, T 34 N, R 8 W, MDM, was made the week of May 21-25 by K. E. Bradshaw, of the Regional Office, and the writer. Localities studied are indicated by circled numbers 1 to 16 on the attached map. We were accompanied by Mr. Jagannath Pandey, Deputy Conservator of Forests in India, who was present as a part of his training in this country. The study was made pursuant to Forest Service memorandum of agreement with the Bureau of Reclamation dated September 30, 1955, under which the Forest Service was to investigate and report on vegetation, soil, and erosion conditions in the watershed. Previous reports of related work are contained in the following memoranda to T. R. Littlefield from K. E. Bradshaw (M-SOILS-General; M- COOPERATION -Bureau of Reclamation (Trinity River Project), on file in the Regional Office:

> November 26, 1954. Report of a vegetation-soil reconnaissance of the East Weaver Creek watershed; describes "new" soils and discusses land use problems in that drainage.
>
> March 1, 1956. Report of Bradshaw's February 1956 examination of the Trinity Project Watershed; describes the area, its vegetation, its soils, and its geology.
>
> June 1, 1956. Supplemental report of soils information gathered in examination of May 1956 with Gleason and Pandey.

Purpose of the current examination was to appraise the effects of logging and burning upon soil erosion as a factor affecting the probable sedimentation in and therefore the life of the new Trinity Reservoir. Fulfillment of this purpose was impossible because quantitative data taken over a period of years would be required to determine the effects of land use upon erosion in this area. Nevertheless, it was possible to determine in a qualitative way what the main land use problems are, and to suggest some ways of solving them toward prolonging life of the reservoir.

Several new soil series were described and mapped in this examination by Bradshaw, as reported in his memorandum of June 1, 1956. In his report the name "Shaver-like" designated a soil resembling the already established Shaver series; names for new soils described in this examination are shown in quotation marks, like "Honeymoon".

Ownership of land in the watershed is about half private and half government, the holdings alternating checkerboard fashion (Map). Well over half of the private land is held by the Southern Pacific Railroad Company as original railroad grant sections. Much of the remaining private land is held in small mining claims by many owners.

OBSERVATIONS

Topography of the drainage area that will remain above water after construction of the dam is steep to very steep. Forested slopes were found commonly with gradients of 65 to 90 percent.

Principal land uses in the area have included hydraulic mining, gold dredging, cultivation, recreation, grazing, road construction, and logging. Hydraulic mining was stopped years ago and its resumption is doubtful; we saw no active erosion source areas caused by early hydraulic work. Small mining claims did not appear to be a significant source of eroded material at the present time in the areas visited.

Gold dredges have operated in the Trinity River channel in the area to be flooded by the reservoir (fig. 1), and one dredge is reported in the upper reaches of Coffee Creek. Existing tailings piles along the main river will be at the bottom of the reservoir, leaving only the Coffee Creek dredge as a potential source of erosion debris. No information was obtained on the future operation of this dredge, nor as to the possibility of dredging other tributary streams. If dredging is permitted in the tributaries it could cause very rapid sedimentation of the reservoir, not only by fines but by the washing-in of coarse tailings (fig. 2).

Cultivation has been practiced locally in the broad valley bottoms, but practically all of these areas will be flooded by the reservoir. Recreation use is heavy in the watershed, but there was no evidence that it had influenced erosion or water quality. There have been very few forest fires in recent years, and all of them were small; accordingly, burning has not caused appreciable erosion.

We saw no signs of accelerated erosion resulting from present or past grazing use, as the slopes observed were mostly timbered. In 1946 Swenson[1/] reported range conditions over the entire forest had improved during the last 40 years with the cessation of use by sheep. He also noted that over-grazing by cattle and horses was continuing. He reported that mountain meadows in the Stuart Fork and East Fork of Stuart Fork drainages were erosion problem areas because of gullying. Of 8 meadows reported, he assigned first priority for erosion control treatment to only 2: Stonewall Meadow, federally-owned; and Morris Meadow, privately owned. Erosion control work was done on several of the meadows by the Forest Service in 1945, and it is to be expected that these meadows will be effectively controlled if the work is completed and maintained adequately.

1/ Swenson, Marriner. Erosion survey problem area and water management inventory, Trinity National Forest. March 1946. (Regional Office report; no file designation.)

Roads

Although the Trinity Project Watershed is still relatively undeveloped, it contains approximately 360 miles of mapped roads plus an undetermined mileage of minor roads and tractor roads built for logging. The mapped roads are of three classes. Class 1 includes main routes linking towns and crossing the watershed; they are a full two traffic lanes wide (fig. 3). Class 2 consists of lateral feeder routes usually 1 to $1\frac{1}{2}$ lanes wide , with turn-outs. Class 3 comprises minor 1-way roads (fig. 4). At present, practically all of these roads are unsurfaced. Approximately 70 miles of roads will be inundated by the reservoir, requiring relocation or abandonment. Road mileages in the 3 classes have been scaled roughly from the map as follows:

Class	Present mileage	Mileage to be inundated
1	114	32
2	70	17
3	109	22
	293	71

The existing roads have some overcast slopes that are eroding, and many cut-banks that have been made unstable by under-cutting through widening of the road surface. On dirt roads the practice of building a shoulder berm in summer, and then pushing it onto the overcast slope before the winter storms, is often responsible for appreciable soil loss. If erosion is to be held to the minimum, unstable slopes should be stabilized by reducing their gradients to the angle of repose. Some of them may require planting, seeding, or even wattling. Berms should be kept year-round where possible, and the sloughed material from cut-banks should be end-hauled for permanent storage instead of being overcast. Surface drainage should be improved on many of the roads, and some culverts should be enlarged (figs. 3 and 5).

The Slate Creek Cutoff in Secs. 2, 3, and 9 of T34N, R9W, is an example of an existing road that will probably require special treatment for erosion control. In 1946 Swenson reported problems involving drainage, culvert outfalls, and eroding banks along this road, and gave it first priority for erosion control treatment. It is a Forest Service road. In May 1956 the road was reported impassable because of washouts and slides during the past winter. Inasmuch as it is a short road that will dead end in the new reservoir, its

abandonment appears likely. If it is to be abandoned, it should be "put to bed" in accordance with suggestions given on pages 70-75 of "A Guide to Erosion Reduction ..."2/.

An example of severe erosion caused by a minor, unmapped road was seen in the Deacon Creek drainage in Sec. 27, T38N, R9W (map reference 11). For most of its length this road, which improved an old mining road, had been very well cross-drained, and had caused no appreciable acceleration of erosion. At one point, however, the road had been relocated with a fill across the stream (fig. 5). The 10-inch culvert in the fill was far too small; consequently, the stream was diverted by the fill and the water cut a new channel down the hillside. Several hundred cubic yards of sand, gravel, and stones washed down from the new channel had practically filled a small pond below (fig. 6). Flowing out of the pond to re-enter its natural channel, the stream cut another large gully in the mountainside. The debris from this gully was undoubtedly washed into Coffee Creek, a main tributary of the new reservoir. This damage could have been prevented by adequate planning and installation. While such erosion sores yield relatively little debris individually, taken all together they are probably a significant source of sediment.

Logging

Logging has only just begun in the Trinity Project Watershed, and a great deal of timber remains to be harvested. As this timber is expected to be cut on a sustained yield basis, logging may be expected to continue as one of the primary land uses of the future. In logging of the past 2 or 3 years that we observed it was clear that, while soil stabilization measures had been employed on a few of the jobs, most of the operations had been carried out without measures to prevent or retard surface runoff and soil erosion.

Good logging practices were observed on steep topography in the Jerry Crew sale of national forest timber in the East Fork of Stuart Fork, Sec. 6, T35N, R8W (map reference 8). The slopes being logged had a gradient of 65 percent. Two soils were present, identified as "Ramshorn" and Shaver-like. The layout of tractor roads and skidtrails was well planned. The main tractor road (fig. 7) had a gradient of 45 percent, but it was located on a sidehill so that it would be possible to install effective cross-drains before the winter storms. Lateral tractor trails feeding the main tractor road had gradients of about 15 to 25 percent (fig. 8).

2/ Forest Service, California Region. A guide to erosion reduction on national forest timber sale areas. 1954. 78 pp. illus.

Logs were skidded straight down the steep hillsides to a lateral, along it to the main tractor road, and down it to the landing on the truck road. The logging on 65 percent slopes caused soil disturbance, but a great deal of litter was left on the ground and erosion that occurred locally was quickly dissipated. Last year's logging skidtrails were well drained, and waterbreaks had already been installed in trails where logging had been completed this spring. The logging plan is sketched in Figure 9A.

Mr. Crew said that he would not normally have logged the area in this way. His normal procedure would have been to log straight down the slopes to the bottom of a small lateral drainage, and then down it to the landing on the truck road (fig. 9B). However, the Forest Service had laid out the tractorway and skidtrail plan, and had required the installation of adequate cross-drains. I asked Mr. Crew how much extra cost was involved in logging by the prescribed plan instead of by customary methods. He said he had been allowed some extra in the sale price to help pay for the additional work, and that the cross-drains would probably cost him about $1.00 per thousand board feet. Mr. Crew was quite pleased when I pointed out to him the effectiveness of his work in preventing loss of soil from that hillside to the stream below.

Poor logging practices were found without exception on the privately owned lands that we visited. Logging was done with no regard for soil disturbance or the possibility of erosion. An example of this kind of logging was found on "Honeymoon" soil in the lower canyon of Van Ness Creek, Sec. 19, T35N, R7W (map reference 15). A tractor road straight down a 60 percent slope, an example of poor location, had been eroded to bedrock (fig. 10). Moderately severe erosion occurred on a tractor road of 29 percent gradient, owing to the absence of cross-drains (fig. 11). Moreover, wet weather logging had caused soil compaction and a cement-like coating on the disturbed soil surface; it appeared likely that this would reduce infiltration and favor surface runoff and erosion next winter.

Salvage logging was seen only in the Ladyslipper burn of 1953, on "Ramshorn" soil in the drainage of Deacon Creek, tributary to Coffee Creek, in Sec. 26, T38N, R9W (map reference 11). This was a government sale. The logging roads and skidtrails were steeper than on the Jerry Crew sale, and most of the roads had adequate cross-drains. No appreciable erosion evidence was found in the sale (fig. 12). The area lay at about 5,000 feet elevation and probably was covered by snow during the winter.

Four plots that had been clear-cut and burned by the Forest Service in 1955 were examined in Sec. 4, T35N, R8W (map reference 9). They lay on "Weaverville" soil near the mouth of East Fork of Stuart

Fork at an elevation of approximately 2,900 feet. Deposits of fresh sediment in the watercourses draining Plots 1 and 2 were found to have come as much from the road along the foot of each plot as from the plots themselves (fig. 13). An uncut strip left along the main stream below Plot 3 undoubtedly prevented eroded material from reaching the stream (fig. 14). No erosion evidence was found on the logged and burned slopes themselves (fig. 15), although the hillside drainage channels showed signs of local down-cutting (fig. 16).

The lack of erosion during the past winter on these plots may be the result of snow cover reported to have been there. When examined in May, the soil remained practically bare and there was practically no Douglas-fir reproduction. This expanse of bare soil is regarded as an erosion threat which will remain until the plots are again covered by vegetation. Severe erosion could occur on the plots if they are hit by summer convectional storms, which often produce high rainfall intensities, or in the early winter storms before snow comes. A 50-foot transect was established in Plot 2 for the measurement of erosion (fig. 17).

SOIL EROSIBILITY

Erosion evidence was noted on the several soils examined, as a basis for suggesting the amount of care required to avoid unnecessary soil loss in logging. It was clear that soils developed on granite parent material, such as the Shaver-like soil, were highly erosible. The acid igenous rocks, commonly referred to as granites, on which these soils are developed occupy about 25 percent of the watershed area (Map). Shaver-like soil was observed in the Stuart Fork north of Trinity Alps Resort (map reference 4) and in the East Fork of Stuart Fork (map reference 5). Erosibility of all the other soils observed was classed tentatively as "moderate" or"low". The erosibility rating for each soil, the locality where it was observed, and its map reference number are given in Table 1. The tentative nature of these erosibility ratings is to be emphasized, as more study of the soils and weather records may change the ratings.

The low to moderate degrees of erosion observed on most of the soils examined may also have been related to the presence of snow, inasmuch as most of the observations were made at elevations of 2,900 feet or above. The amount of bare, disturbed soil remaining in many of the logged areas, together with the lack of drainage facilities on logging roads and skidtrails, invites severe erosion in summer convectional stormsas well as in fall and winter rains.

Table 1.--Tentative appraisal of soil erosibility in Trinity Project Watershed based on observations of field trip May 22-25, 1956

Erosion class and soil	Parent Material[1/] Symbol	Parent Material[1/] Name	Where observed, map reference
High			
Shaver-like	Jai	Granite	Stuart Fk., Trinity Alps (4); EFK Stuart Fork (8)
Not identified	Jai	Granite	Coffee Crk., Golden Jubilee (12)
Moderate			
"Honeymoon"	Cm	Marine meta-sediments	Van Ness Crk. (15) (16)
Not identified	Jub	Ultra-basic intrusives	Coffee Crk. borrow pit (13)
"Ramshorn" shallow	Jub	Ultra-basic intrusives	Stuart Fork, Elk Gulch (3a)
Low			
"Weaverville"	Eu	Marine sediments	Buckeye Crk., Montgomery Ridge (1) (2); Stuart Fk., Cedar Stock Farm (5), EFK Stuart Fk Cut-Burn plots (9)
"Weaverville"	Qg	Glacial deposits	Preacher Mdw. (10)
"Ramshorn" deep	Jub	Ultra-basic intrusives	EFK Stuart Fk. (8), Lady slipper burn (11)
"Siphon"	pre€	Metamorphics	Stuart Fk. at Bridge camp (3)
Boomer-like	pDv	Meta-volcanics	E. Fk. Stuart Fk. (7)
Not identified		Igneous	Squirrel Crk. nr. Squirrel Flat (14)

1/ From Geologic Map of California, by Olaf P. Jenkins, 1938.
- Cm Mississippian marine meta-sediments
- Eu Upper Eocene marine sediments; uplifted and dissected old terrace formations
- Jai Jurassic acid intrusives
- Jub Jurassic ultra-basic intrusives
- pre€ Pre-Cambrian metamorphics
- pDv Undivided Pre-Devonian meta-volcanics
- Qg Quarternary gravels

RESERVOIR SEDIMENTATION

Expected sedimentation rate for the new Trinity Reservoir has been estimated by the U. S. Bureau of Reclamation at 0.26 acre-feet per square mile of drainage area per year. The rate is based on sediment content of the Powder River below Mason Dam Site, Oregon3/. The sediment measured was derived in part from gold dredge operations. In applying the 0.26 acre-foot figure to the Trinity Project the Bureau concluded that conditions were comparable on both streams and that, while some sediment would be deposited in estuaries where streams enter the reservoir, the bulk of it would occupy space reserved for dead storage and thus would not affect reservoir operation. The Bureau estimated that less than 20,000 acre-feet of storage space would be occupied by sediment in the first 100 years after the dam is built, and concluded that "... sedimentation will have no appreciable adverse effects upon reservoir capacity within the foreseeable future, unless present watershed conditions are materially changed due to such factors as forest fire or unwise logging operations."

In considering these estimates it should be kept in mind that the dredging debris measured in the Powder River was probably suspended load composed of fine soil components. Such fines are carried far by flowing water, and tend to be well distributed over the bottom of a reservoir. Erosion debris from logged areas and roads of the Trinity Project Watershed contains fines, but also many larger particles including sand, gravel, stones, and even boulders. The heavier components of this debris will almost certainly not be carried to the dead storage area in the deepest part of the reservoir, but will form deltas near the high water line occupying some of the space useful for water storage and thereby depleting reservoir capacity (fig. 18). Thus erosion from road building, logging, and other watershed disturbances directly affects the useful capacity of the reservoir; it is the basis for the Bureau's reservation, quoted above, as to the effects of forest fire or unwise logging operations.

Everything considered, the 0.26 acre-foot sedimentation rate forecast by the Bureau appears low. It is equivalent to 450 tons per square mile. For similar geologic types and precipitation in Western Oregon, Anderson4/ gives 500-700 tons per square mile as the contribution

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3/ U. S. Bureau of Reclamation. Trinity River Diversion. Central Valley Ultimate Plan. January 1952. (pp. 50-52).

4/ Anderson, Henry W. Suspended sediment discharge as related to streamflow, topography, soil, and land use. Transactions, American Geophysical Union, 35(2):268-81. April 1954.

of forest lands under present use, and 3 times this amount under future full use. Inasmuch as Anderson's estimate relates to suspended sediment, which includes only clay and silt amounting to about 80 percent of the soil volume, it appears that the total yield of debris to Trinity Reservoir might be even higher.

That the 0.26 figure is low is suggested also by a sedimentation survey of Misselbeck Reservoir (Rainbow Lake) which lies about 20 miles south of Trinity Dam Site. Misselbeck Dam is located in Sec. 31, T31N, R7W, on the North Fork of Cottonwood Creek, Shasta County. It differs from the Trinity in that its watershed lies entirely in a zone of granitic rocks while granite is found in only about 25 percent of the Trinity watershed. The topography and plant cover are similar. Sedimentation in Misselbeck Reservoir occurred from 1920 to 1945 at the rate of 0.70 acre-feet per square mile of drainage area per year, according to the Soil Conservation Service5/. This rate was established before appreciable logging was done, and before the Rainbow fire of 1950. It is probable that a substantially higher sedimentation rate would be found if the reservoir were re-surveyed now, owing to severe erosion caused by logging, logging roads, and burning.

Tributary to the three main arms of the new Trinity Reservoir are some 440 square miles of watershed lands, a large part of which are subject to logging, but which must first be made accessible by road construction. That road construction alone can cause the delivery of appreciable debris to the reservoir is suggested by the data from some other roads in California on which erosion losses have been measured. The North Fork Forest Highway, a 20-foot road in Madera County, lost 0.87 acre-feet of detritus per mile during the second winter after construction, as calculated from the amount of end-haul material required to replace washed-out fills and overcast slopes6/. The Glendora Mountain Road, approximately 24 feet wide, in Los Angeles County, lost 50 acre-feet per mile per year during the first 2 winters after construction; this was measured in a reservoir7/. The Angeles Crest Highway, about 30 feet wide and also in Los Angeles County was eroded in the major storms of February-March 1938 at an estimated rate of 62 acre-feet per mile8/ (fig. 19).

5/ Brown, Carl B. and Eldon M. Thorp, Reservoir sedimentation in the Sacramento-San Joaquin drainage basins, California. SCS Spec. Report 10, July 1947. 69 pp.

6/ Muir, D. M. Erosion control on forest highways. December 1937. (RI-GENERAL-Erosion Control-Roads)

7/ Kraebel, Charles J. Erosion control on mountain roads. USDA Circ. 380.

8/ Field estimate by the writer.

These cases suggest the severity of erosion that can occur along major roads such as those that will probably be built to replace Class 1 routes inundated by Trinity Reservoir. Minor roads such as the logging access routes now being opened up may cause less erosion per mile, but their greater length could discharge appreciable quantities of debris to the reservoir. There are no studies of the Trinity area on which to base estimates of erosion resulting from road construction and logging in the watershed, and estimates were not made in the current examination. Nevertheless, it is clear that the best erosion control practices must be applied if reservoir sedimentation is to be kept at a minimum.

FUTURE WATERSHED MANAGEMENT

The need for prolonging the life of the new reservoir will make it desirable to keep track of its rate of sedimentation and of land use practices that tend to accelerate erosion in the watershed. It is assumed that the Bureau of Reclamation will have periodic surveys made of the reservoir bottom to determine how fast storage capacity is being lost. To the Forest Service, as the agency responsible for managing roughly one-half of the watershed land, will fall the responsibility for preventing accelerated erosion, and for controlling it when it does occur.

The very best planning and construction techniques to prevent erosion will be required in re-locating roads flooded by the reservoir. The prevention of erosion along other roads and in logging areas will require careful planning of each operation, alert supervision while it is under construction, and adequate maintenance. This is especially true in parts of the watershed having soils derived from granite (Map). Effective fire prevention and suppression activities should be continued to keep the burned acreage at its low figure of recent years.

Standards and specifications for the location and construction of Forest Service roads are given in the Road Handbook[9]. Guide lines for minimizing erosion connected with logging and the construction of logging roads and skidtrails are given in "A Guide to Erosion Reduction ..." (footnote 2, page 6). The stabilization of eroding road surfaces and slopes, both now and in the future, may require the use of techniques described in "Erosion Control on Mountain Roads" (footnote 7, page 11). Guide lines for the repair of gullies in mountain meadows, and for their proper grazing use, are available from the Experiment Station.

9/ U. S. Forest Service, Division of Engineering. Road handbook standards, construction, maintenance, structures, transportation planning.

Setting up good cooperative relations with the other large land owner in the watershed - the Southern Pacific Railroad Company - so that operations on both ownerships can be planned as a unit and conducted with adequate attention to soil and water values will go far to meet the management challenge in the Trinity Project Watershed. Allowances in stumpage rates will have to be made on timber sales to offset the greater cost of watershed protection, a practice that is already begun.

Gaining the cooperation of lesser private land owners, the loggers, and the road builders may be a real challenge in public relations. A first step in this direction appears to be putting good practices into effect on the government land. This requirement met, the challenge will be to local forest officers to explain the "why" of this work, and to get private industry to follow the government example. With such a program well carried out there appears to be no reason why the Trinity Project Watershed cannot take its place as a model example of integrated land use, to prolong the life of Trinity Reservoir and point the way for other operations to reduce the watershed damage now being done needlessly by careless logging and road construction in northern California.

CHG - 6657

Figure 1.--Gold dredge in Trinity River above Stringtown. The tailings piles at right are below spillway level of the new Trinity Dam. May 24, 1956.

FAC - 2-16-56 - 16

Figure 2.--Large quantities of gold dredge tailings were washed away by Trinity River during winter of 1955-56. This would have caused great loss of storage capacity if a reservoir existed downstream. Feb. 16, 1956.

CHG - 6644

Figure 3.--Main road from Weaverville to Trinity Center and Callahan in Hobel Crk. drainage. Roadside ditch has been eroded by heavy flow resulting from insufficient number of culverts. The 24-inch culvert at left was plugged by debris causing heavier erosion farther down road. May 23, 1956.

CHG - 6634

Figure 4.--Minor roads with typically gullied ruts, result of lack of cross-drains. The gullies are cut to parent material. Baxter Gulch drainage, Sec. 14, T34N, R9W. May 22, 1956.

CHG - 6660

Figure 5.--Relocation of old mining road required through-fill across stream. The 10-inch culvert, marked by man, was too small; consequently, the fill diverted the stream. Severe erosion occurred where the stream cut its new channel below. May 24, 1956.

CHG - 6661

Figure 6.--Debris from the stream diversion shown above was trapped in a small pond below road. Diverted stream spilling from pond cut a new channel, washing large quantity of soil and rock from hillside below. May 24, 1956.

CHG - 6649 C

Figure 7.--Main tractor road on Jerry Crew sale; gradient 45%, but road located to allow construction of cross-drains. Lateral tractor road enters at left center. Landing is on truck road below. May 23, 1956.

CHG - 6651

Figure 8.--Tractor-built cross-drain (marked by 3 ft. line-rod) was effective in diverting runoff and preventing erosion on this lateral tractor road on the Jerry Crew sale. May 23, 1956.

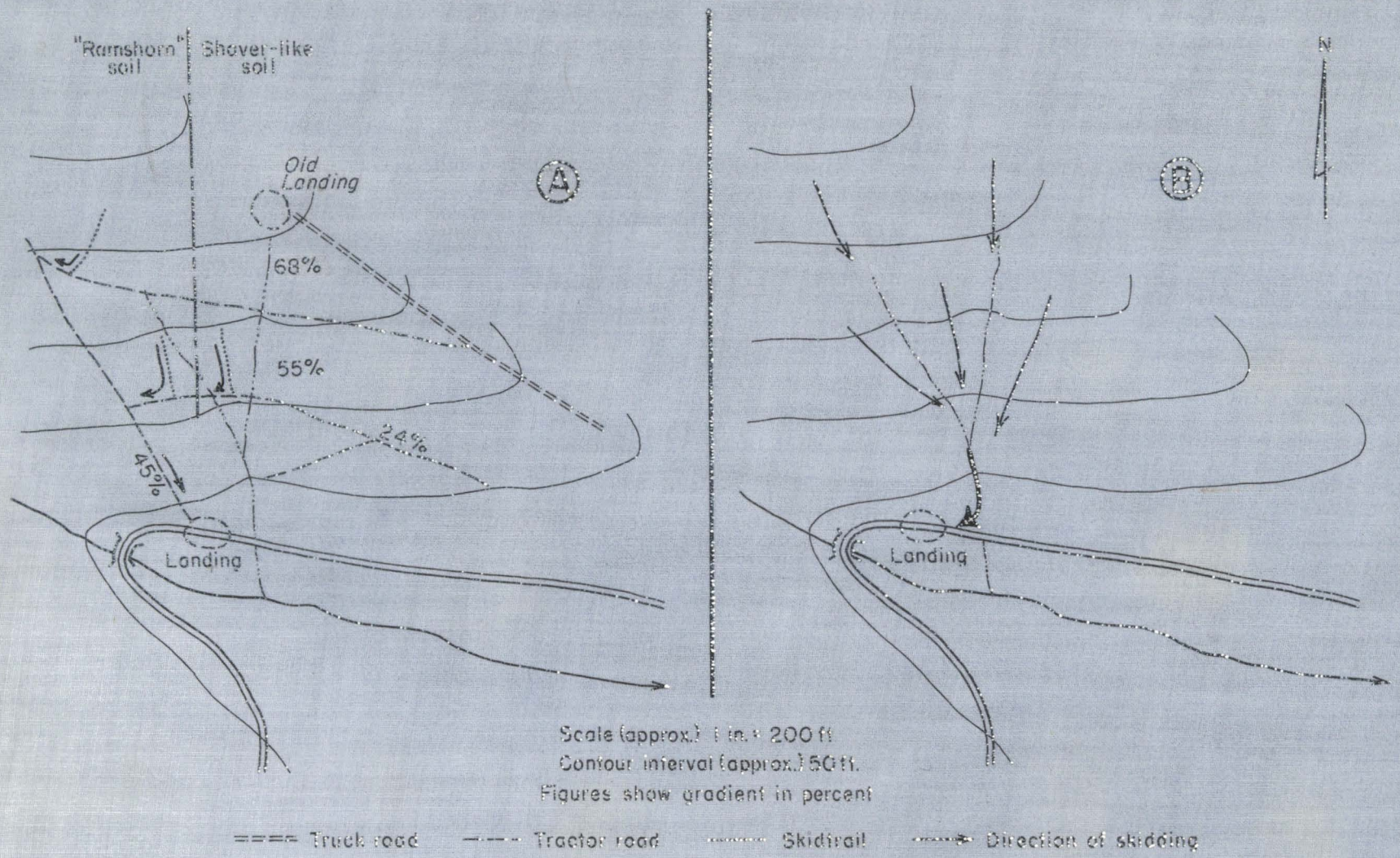


Figure 9.--Field sketch of Jerry Crew timber sale, Shasta-Trinity N. F., Sec. 6, T35N, R8W. A. How job was done: tractor roads located in advance to permit installation of cross-drains. B. Usual practice in logging slopes of this type: no tractor roads, logs skidded straight down slopes and drainage bottoms, no cross-drains.

CHG - 6672

Figure 10.--Tractor road poorly located on 60 percent slope; neither drainage nor litter cover was installed, resulting in severe erosion exposing bedrock. Private logging operations in Van Ness Creek drainage, Sec. 19, T35N, R7W. May 25, 1956.

CHG - 6673

Figure 11.--Tractor road well located with 29 percent gradient on hillside was eroded owing to absence of cross-drains; note fresh deposition in left foreground and center. Same area as photo above. May 25, 1956.

CHG - 6659

Figure 12.--Snow cover and stoniness of ground probably prevented erosion of this salvage-logged area. Heavy erosion pavement, 0.8 density, covers hillside. Permanent cover now is huckleberry oak; Ponderosa pine 2-2 stock planted fall 1953 doing well. Ladyslipper burn of 1953, Deacon Creek drainage. May 24, 1956.

CHG - 6655

Figure 13.--As much erosion debris came from road as from this clear-cut-and-burned plot the first winter after treatment. Slope gradients 42-45 percent. Plot 1 in E. Fk. of Stuart Fk. drainage. May 23, 1956.

CHG - 6665

Figure 14.--Uncut "leave" strip along stream prevented road and burn erosion from entering creek, a good logging practice. E. Fk. of Stuart Fk. plots. May 25, 1956.

CHG - 6666

Figure 15.--Lack of erosion on 39 percent slope on clear-cut-and-burned plot, shown by clear prints of tractor and absence of rills and gullies. Soil is believed to have been protected by snow cover during heavy winter storms. May 25, 1956.

CHG - 6669

Figure 16.--Main drainage of clear-cut-and burned Plot 2 shows only local down-cutting; slopes not appreciably eroded. May 25, 1956.

CHG - 6670

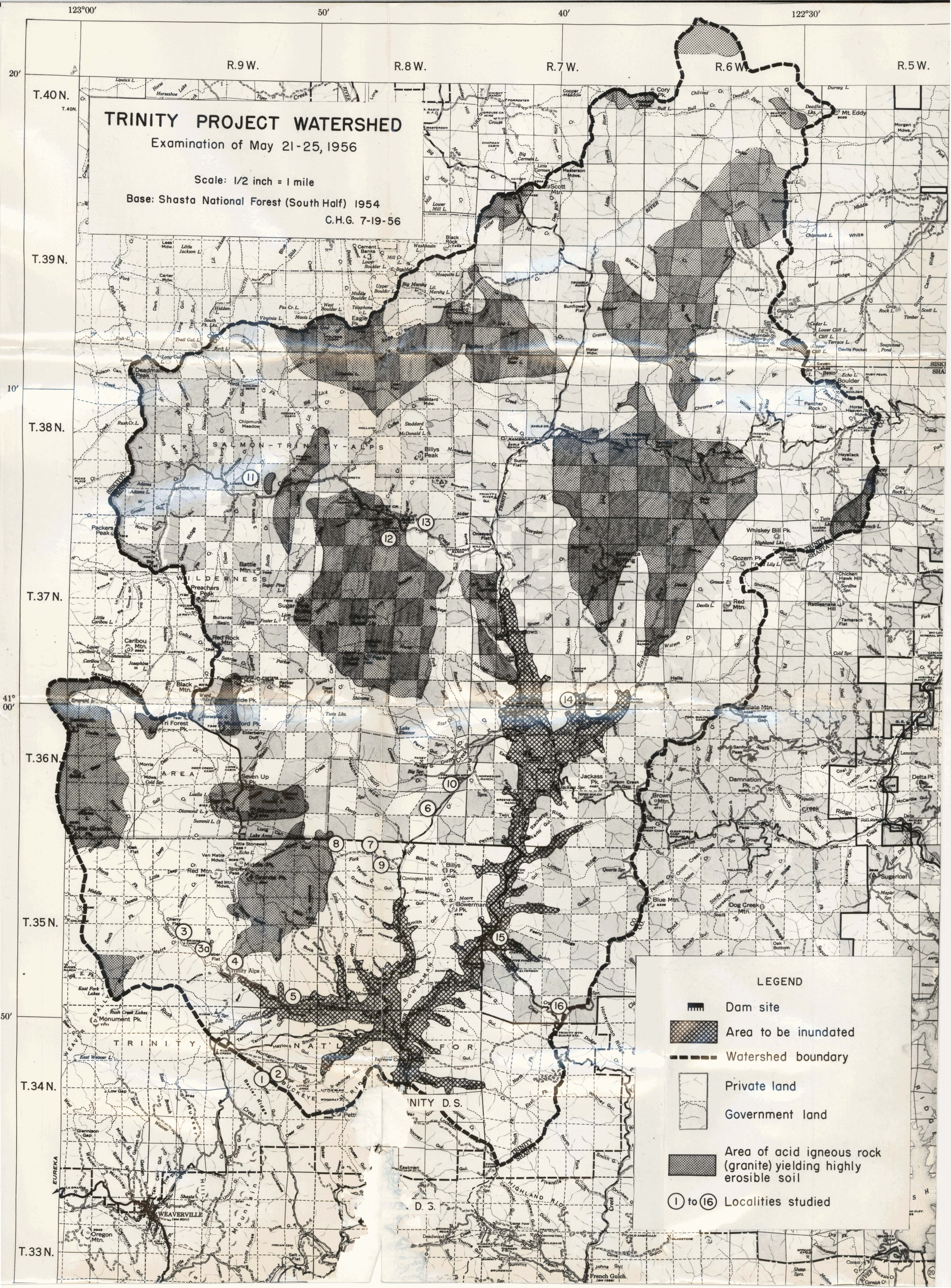
Figure 17.--Gully transect installed in clear-cut-and-burned Plot 2 for measurement of erosion; transect ends are marked by iron stakes 50 feet apart. J. N. Pandey and K. E. Bradshaw in view. May 25, 1956.

CHG - 6631

Figure 18.--Erosion debris in the Spring Creek estuary of Keswick Reservoir, Sacramento River, has formed a delta that depletes the useful storage capacity of the reservoir. The debris consists of fines as well as larger rock particles. May 21, 1956.

CHG - 1467

Figure 19.--Erosion estimated at 62 acre-feet per mile of road occurred in a single large storm on Angeles Crest Highway, Los Angeles County. Inadequate drainage and overcast slope treatment caused this soil loss. March 14, 1938.


TRINITY PROJECT WATERSHED
Examination of May 21-25, 1956
Scale: 1/2 inch = 1 mile
Base: Shasta National Forest (South Half) 1954
C.H.G. 7-19-56
123°00′
50′
40′
122°30′
20′
10′
41° 00′
50′
R.9 W.
R.8 W.
R.7 W.
R.6 W.
R.5 W.
T.40 N.
T.39 N.
T.38 N.
T.37 N.
T.36 N.
T.35 N.
T.34 N.
T.33 N.
SALMON-TRINITY-ALPS
WILDERNESS
TRINITY
NAT'L
FOR.
AREA
TRINITY D.S.
D.S.
WEAVERVILLE
Cory Pk.
Mt. Eddy
Scott Mtn.
Black Rock
Cement Banks
Eagle Pk.
Deadman Peak
Chipmunk Meadow
Billys Peak
Packers Peak
Battle Mtn.
Preachers Peak
Sugar Pine
Red Rock Mtn.
Caribou Mtn.
Black Mtn.
Tri Forest Pk.
Seven Up Pk.
Red Mtn.
Middle Pk.
Trinity Alps
Monument Pk.
Boulder Pk.
Panther Rock
Whiskey Bill Pk.
Gozem Pk.
Chicken Hawk Hill
Red Mtn.
Rattlesnake Hill
Slate Mtn.
Jackass Pk.
Brown Mtn.
Damnation Pk.
Blue Mtn.
Dog Creek Mtn.
Sugarloaf
Delta Pt.
Oregon Mtn.
Lake Eleanor
Lake Anna
Little Granite
Bowerman Pk.
Billys Pk.
Covington Mill
Moore
Smith
Clawton
Petti
Fairview Ca
Eastman
Deadwood
Summit
French Gulch
Lamoine
Whitlow
Delta
Renfro
Corum
Cornish Cr.
Moccasin Cr.
Oak Bottom
Honeymoon Ridge
Sanford Pass
Damnation Pass
Nelson Creek Gap
Budweiser Gap
Low Gap
Glennison Gap
Shasta Spr.
Salt Flat
Indian Cem.
Trinity House
Mountain
HIGHLAND RIDGE
EUREKA
LEGEND
Dam site
Area to be inundated
Watershed boundary
Private land
Government land
Area of acid igneous rock (granite) yielding highly erosible soil
1 to 16 Localities studied